

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
 in its capacity as elected Office

Date of mailing (day/month/year)
 07 February 2002 (07.02.02)

International application No.
 PCT/IT01/00117

Applicant's or agent's file reference
 689/PCT/CA

International filing date (day/month/year)
 09 March 2001 (09.03.01)

Priority date (day/month/year)
 31 March 2000 (31.03.00)

Applicant

FRANCINI, Gianluca et al

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
 02 November 2001 (02.11.01)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☐ was
☒ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

S. Buttay

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

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From the INTERNATIONAL BUREAU

To:

Commissioner
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 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
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Date of mailing (day/month/year) 04 February 2002 (04.02.02)	Applicant's or agent's file reference 689/PCT/CA
International application No. PCT/IT01/00117	Priority date (day/month/year) 31 March 2000 (31.03.00)
International filing date (day/month/year) 09 March 2001 (09.03.01)	
Applicant FRANCINI, Gianluca et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
 02 November 2001 (02.11.01)

☐ in a notice effecting later election filed with the International Bureau on:

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☒ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer S. Buttay
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PCT

NOTIFICATION OF THE RECORDING
OF A CHANGE

(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

CASUCCIO, Carlo
CSELT - Centro Studi e Laboratori
Telecomunicazioni S.p.A.
Via Reiss Romoli, 274
I-10148 Torino
ITALIE

Date of mailing (day/month/year) 31 January 2002 (31.01.02)	IMPORTANT NOTIFICATION
Applicant's or agent's file reference 689/PCT/CA	
International application No. PCT/IT01/00117	International filing date (day/month/year) 09 March 2001 (09.03.01)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address

CSELT-CENTRO STUDI E LABORATORI
TELECOMUNICAZIONI S.P.A.
Via G. Reiss Romoli, 274
I-10148 Torino
Italy

State of Nationality

IT

State of Residence

IT

Telephone No.

Facsimile No.

Teleprinter No.

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☒ the name ☐ the address ☐ the nationality ☐ the residence

Name and Address

TELECOM ITALIA LAB S.P.A.
Via G. Reiss Romoli, 274
I-10148 Torino
Italy

State of Nationality

IT

State of Residence

IT

Telephone No.

Facsimile No.

Teleprinter No.

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☒ the receiving Office ☒ the designated Offices concerned
☐ the International Searching Authority ☐ the elected Offices concerned
☐ the International Preliminary Examining Authority ☐ other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer S. Buttay Telephone No.: (41-22) 338.83.38
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PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 689/PCT/CA	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/IT 01/ 00117	International filing date (day/month/year) 09/03/2001	(Earliest) Priority Date (day/month/year) 31/03/2000
Applicant CSELT-CENTRO STUDI E LABORATORI TELECOMUNICAZIONI;		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :



contained in the international application in written form.



filed together with the international application in computer readable form.



furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 5



as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.



None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IT 01/00117

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G06T15/70

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, COMPENDEX, IBM-TDB, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 710 929 A (AT & T CORP) 8 May 1996 (1996-05-08) abstract; figures 1-4 column 1, line 11 - line 53 ---	1-7
A	MORISHIMA S ET AL: "FACIAL EXPRESSION SYNTHESIS BASED ON NATURAL VOICE FOR VIRTUAL FACE-TO-FACE COMMUNICATION WITH MACHINE" PROCEEDINGS OF THE VIRTUAL REALITY ANNUAL INTERNATIONAL SYMPOSIUM,US,NEW YORK, IEEE, vol. SYMP. 1, 18 September 1993 (1993-09-18), pages 486-491, XP000457717 abstract; figure 1 page 487, line 1 -page 488, line 39 --- -/--	1-7

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

4 July 2001

Date of mailing of the international search report

13/07/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

König, W

INTERNATIONAL SEARCH REPORT

International Application No

PCT IT 01/00117

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 97 46974 A (ALFONSI PHILIPPE ;PRONIER JEAN LUC (FR)) 11 December 1997 (1997-12-11) abstract; figure 6 -----</p>	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IT 01/00117

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0710929	A	08-05-1996	AU 3668095 A	16-05-1996
			CA 2162199 A	08-05-1996
			JP 8235384 A	13-09-1996
<hr/>				
WO 9746974	A	11-12-1997	FR 2749420 A	05-12-1997
			AU 3265397 A	05-01-1998
			EP 0907934 A	14-04-1999
<hr/>				

22082

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REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference

(if desired) (12 characters maximum) 689/PCT/CA

Box No. I TITLE OF INVENTION	
METHOD OF ANIMATING A SYNTHESISED MODEL OF A HUMAN FACE DRIVEN BY AN ACOUSTIC SIGNAL	
Box No. II APPLICANT	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)	
CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A. Via G. Reiss Romoli, 274 I-10148 TORINO ITALY	<input type="checkbox"/> This person is also inventor Telephone No. +39 011 228 7781 Facsimile No. +39 011 228 5096 Teleprinter No.
State (that is, country) of nationality: ITALY	State (that is, country) of residence: ITALY
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input checked="" type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)	
FRANCINI Gianluca c/o CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A. Via Reiss Romoli, 274 I - 10148 TORINO ITALY	This person is: <input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below)
State (that is, country) of nationality: ITALY	State (that is, country) of residence: ITALY
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
<input checked="" type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet	
Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE	
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: <input type="checkbox"/> agent <input checked="" type="checkbox"/> common representative	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)	
CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A. CASUCCIO Carlo Brevetti e Licenze Via Reiss Romoli, 274 I - 10148 TORINO ITALY	Telephone No. + 39 011 228 7285 Facsimile No. +30 011 228 5096 Teleprinter No.
<input type="checkbox"/> Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent	

Continuation of Box No <u>III</u> FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub-boxes is used, this sheet should not be included in the request</i>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation) The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p>LANDE Claudio c/o CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A. via Reiss Romoli, 274 I - 10148 TORINO ITALY</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: ITALY	State (that is, country) of residence: ITALY
<p>This person is applicant for the purposes of:</p> <p><input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation) The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p>LEPSOY Skjalg c/o CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A. via Reiss Romoli, 274 I - 10148 TORINO ITALY</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: NORWAY	State (that is, country) of residence: NORWAY
<p>This person is applicant for the purposes of:</p> <p><input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation) The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p>QUAGLIA Mauro c/o CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A. via Reiss Romoli, 274 I - 10148 TORINO ITALY</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: ITALY	State (that is, country) of residence: ITALY
<p>This person is applicant for the purposes of:</p> <p><input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation) The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality:	State (that is, country) of residence:
<p>This person is applicant for the purposes of:</p> <p><input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p><input type="checkbox"/> Further applicants and/or (further) inventors are indicated on another continuation sheet</p>	

Box No:Y DESIGNATION OF STATES

The following designations are hereby made under Rule 4(9)(a) (mark the applicable check-boxes; at least one must be marked):

Regional Patent

- ☐ AP ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, MZ Mozambique, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☐ EA Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ EP European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, TR Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☐ OA OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

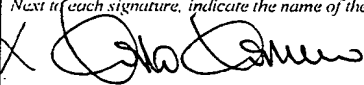

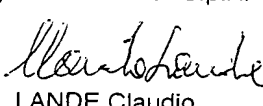
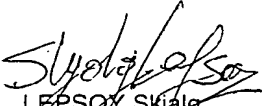
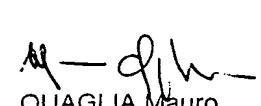
National Patent (if other kind of protection or treatment desired, specify on dotted line):

- | | |
|--|--|
| <input type="checkbox"/> AE United Arab Emirates | <input type="checkbox"/> LC Saint Lucia |
| <input type="checkbox"/> AG Antigua and Barbuda | <input type="checkbox"/> LK Sri Lanka |
| <input type="checkbox"/> AL Albania <input type="text"/> | <input type="checkbox"/> LR Liberia |
| <input type="checkbox"/> AM Armenia <input type="text"/> | <input type="checkbox"/> LS Lesotho <input type="text"/> |
| <input type="checkbox"/> AT Austria <input type="text"/> | <input type="checkbox"/> LT Lithuania |
| <input type="checkbox"/> AU Australia <input type="text"/> | <input type="checkbox"/> LU Luxembourg |
| <input type="checkbox"/> AZ Azerbaijan | <input type="checkbox"/> LV Latvia |
| <input type="checkbox"/> BA Bosnia and Herzegovina <input type="text"/> | <input type="checkbox"/> MA Morocco <input type="text"/> |
| <input type="checkbox"/> BB Barbados | <input type="checkbox"/> MD Republic of Moldova <input type="text"/> |
| <input type="checkbox"/> BG Bulgaria <input type="text"/> | <input type="checkbox"/> MG Madagascar <input type="text"/> |
| <input type="checkbox"/> BR Brazil <input type="text"/> | <input type="checkbox"/> MK The former Yugoslav Republic of Macedonia <input type="text"/> |
| <input type="checkbox"/> BY Belarus <input type="text"/> | <input type="checkbox"/> MN Mongolia |
| <input type="checkbox"/> BZ Belize <input type="text"/> | <input type="checkbox"/> MW Malawi <input type="text"/> |
| <input checked="" type="checkbox"/> CA Canada | <input type="checkbox"/> MX Mexico <input type="text"/> |
| <input type="checkbox"/> CH and LI Switzerland and Liechtenstein | <input type="checkbox"/> MZ Mozambique |
| <input type="checkbox"/> CN China <input type="text"/> | <input type="checkbox"/> NO Norway |
| <input type="checkbox"/> CR Costa Rica <input type="text"/> | <input type="checkbox"/> NZ New Zealand <input type="text"/> |
| <input type="checkbox"/> CU Cuba <input type="text"/> | <input type="checkbox"/> PL Poland <input type="text"/> |
| <input type="checkbox"/> CZ Czech Republic <input type="text"/> | <input type="checkbox"/> PT Portugal <input type="text"/> |
| <input type="checkbox"/> DE Germany <input type="text"/> | <input type="checkbox"/> RO Romania |
| <input type="checkbox"/> DK Denmark <input type="text"/> | <input type="checkbox"/> RU Russian Federation <input type="text"/> |
| <input type="checkbox"/> DM Dominica | <input type="checkbox"/> SD Sudan |
| <input type="checkbox"/> DZ Algeria <input type="text"/> | <input type="checkbox"/> SE Sweden |
| <input type="checkbox"/> EE Estonia <input type="text"/> | <input type="checkbox"/> SG Singapore |
| <input type="checkbox"/> ES Spain <input type="text"/> | <input type="checkbox"/> SI Slovenia <input type="text"/> |
| <input type="checkbox"/> FI Finland <input type="text"/> | <input type="checkbox"/> SK Slovakia <input type="text"/> |
| <input type="checkbox"/> GB United Kingdom | <input type="checkbox"/> SL Sierra Leone <input type="text"/> |
| <input type="checkbox"/> GD Grenada | <input type="checkbox"/> TJ Tajikistan <input type="text"/> |
| <input type="checkbox"/> GE Georgia <input type="text"/> | <input type="checkbox"/> TM Turkmenistan <input type="text"/> |
| <input type="checkbox"/> GH Ghana <input type="text"/> | <input type="checkbox"/> TR Turkey <input type="text"/> |
| <input type="checkbox"/> GM Gambia | <input type="checkbox"/> TT Trinidad and Tobago <input type="text"/> |
| <input type="checkbox"/> HR Croatia <input type="text"/> | <input type="checkbox"/> TZ United Republic of Tanzania |
| <input type="checkbox"/> HU Hungary <input type="text"/> | <input type="checkbox"/> UA Ukraine <input type="text"/> |
| <input type="checkbox"/> ID Indonesia | <input type="checkbox"/> UG Uganda <input type="text"/> |
| <input type="checkbox"/> IL Israel <input type="text"/> | <input checked="" type="checkbox"/> US United States of America <input type="text"/> |
| <input type="checkbox"/> IN India <input type="text"/> | <input type="checkbox"/> UZ Uzbekistan <input type="text"/> |
| <input type="checkbox"/> IS Iceland | <input type="checkbox"/> VN Viet Nam <input type="text"/> |
| <input checked="" type="checkbox"/> JP Japan <input type="text"/> | <input type="checkbox"/> YU Yugoslavia <input type="text"/> |
| <input type="checkbox"/> KE Kenya <input type="text"/> | <input type="checkbox"/> ZA South Africa <input type="text"/> |
| <input type="checkbox"/> KG Kyrgyzstan <input type="text"/> | <input type="checkbox"/> ZW Zimbabwe <input type="text"/> |
| <input type="checkbox"/> KP Democratic People's Republic of Korea <input type="text"/> | |
| <input type="checkbox"/> KR Republic of Korea <input type="text"/> | |
| <input type="checkbox"/> KZ Kazakhstan <input type="text"/> | |

Check-box reserved for designating States which have become party to the PCT after issuance of this sheet:

☐

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4(9)(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

Box No. VI PRIORITY CLAIM		<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box <input type="checkbox"/>		
Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country	regional application: regional Office	international application: receiving Office
item (1) 31 MARCH 2000	TO2000A000303	ITALY		
item (2)				
item (3)				
<input checked="" type="checkbox"/> The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): <i>* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4(10)(b)(ii)) See Supplemental Box</i>				
Box No. VII INTERNATIONAL SEARCHING AUTHORITY				
Choice of International Searching Authority (ISA) <i>(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen: the two-letter code may be used):</i>		Request to use results of earlier search: reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority): Date (day/month/year) Number Country (or regional Office)		
ISA /				
Box No. VIII CHECK LIST: LANGUAGE OF FILING				
This international application contains the following number of sheets: request : 4 description (excluding sequence listing part) : 13 claims : 2 abstract : 1 drawings : 6 sequence listing part of description : Total number of sheets : 26		This international application is accompanied by the item(s) marked below: 1 <input checked="" type="checkbox"/> fee calculation sheet 2 <input type="checkbox"/> separate signed power of attorney 3 <input type="checkbox"/> copy of general power of attorney; reference number, if any: 4 <input type="checkbox"/> statement explaining lack of signature 5 <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s): 6 <input type="checkbox"/> translation of international application into (language): 7 <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material 8 <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form 9 <input type="checkbox"/> other (specify):		
Figure of the drawings which should accompany the abstract: 2		Language of filing of the international application: ENGLISH		
Box No. IX SIGNATURE OF APPLICANT OR AGENT				
<i>Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request):</i>				
 CASUCCIO Carlo - Attorney in fact CSELT S.p.A.				
 FRANCINI Gianluca  LANDE Claudio  LEPSOY Skala  QUAGLIA Mauro				

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1 <input type="checkbox"/> Date of actual receipt of the purported international application:		
3 <input type="checkbox"/> Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4 <input type="checkbox"/> Date of timely receipt of the required corrections under PCT Article 11(2):		
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FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International application No

Date stamp of the receiving Office

Applicant's or agent's
file reference 689/PCT/CA

Applicant
cselt S.p.A. et al.

CALCULATION OF PRESCRIBED FEES

1 TRANSMITTAL FEE ITL 60.000 T

2 SEARCH FEE ITL 1.829.775 S

International search to be carried out by
(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search)

3 INTERNATIONAL FEE

Basic Fee

The international application contains 26 sheets

first 30 sheets 791.934 b1

remaining sheets x additional amount = b2

Add amounts entered at b1 and b2 and enter total at B 791.934 B

Designation Fees

The international application contains 4 designations

4 x 170.392 = 681.568 D

number of designation fees payable (maximum 6) amount of designation fee

Add amounts entered at B and D and enter total at I 1.473.502 I

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4 FEE FOR PRIORITY DOCUMENT (if applicable) P

5 TOTAL FEES PAYABLE 3.363.277

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The designation fees are not paid at this time

MODE OF PAYMENT

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I - 10148 TORINO: **10 LUG. 2001**
Via Guglielmo Reiss Romoli, 274Protocollo N. TR/IP **001631**The International Bureau of WIPO
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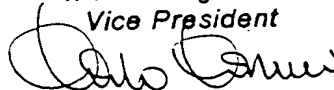
Oggetto

We hereby inform you that on February 26, 2001, the Extraordinary Shareholders' Meeting of CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A. resolved to change the company name from "CSELT - Centro Studi e Laboratori Telecomunicazioni S.p.A." to "**Telecom Italia Lab S.p.A.**". The company's registered offices (Via Guglielmo Reiss Romoli, 274 - 10148 Torino), entry number in the Registry of Business Enterprises of Torino and tax code number (00527770010) remain unchanged.

Please record the change in the name of applicant for the following PCT applications:

1. International application No. PCT/IT01/00063. International filing date 13.02.2001. Applicant's file ref. 686/PCT/CA
2. International application No. PCT/IT01/00117. International filing date 09.03.2001. Applicant's file ref. 689/PCT/CA

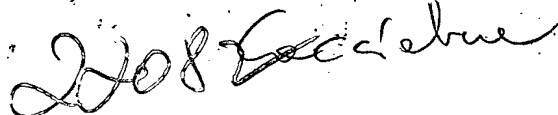
Best regards

Telecom Italia Lab S.p.A.
IPR Management
Vice President

CA/lr

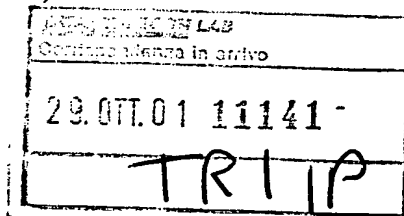
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Ihre
Your**Ref: CB 612 WO/E**Unsere
Our**Ref: EP 98913710.4**

19th October, 2001/ch

Re: European Patent Application 98 913 710.4
(International Patent Application PCT/EP 98/01433)
Inv.: Bellifemine et al.

Dear Sirs,

At first, please be informed that we filed a petition requesting to update the official register with respect to the change of name from CSELT to Telecom Italia Lab S.p.A. A copy of our petition is enclosed.

With reference to our letter of 21st August, 2001, this is to report that we have received the decision to grant the European patent. Please find enclosed a copy of the written decision.

According to the written decision, mention of grant in the European Patent Bulletin will take place on

21st November, 2001.

Please note that this date is of importance with reference to the term for filing translations of the patent specification and claims in the different countries. Please note that the translations are to be filed within terms expiring as follows:

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Luxembourg, the Netherlands, Portugal, Spain, Switzerland, Sweden and Italy: within three months from the date mentioned = 21st February, 2002.

Further, from the mention of grant, the annuities will have to be paid with the national authorities. In Great Britain, the next annuity payment will be due on 12th March, 2002, whereas in the remaining designated countries the next annuity payments will be due on 31st March, 2002.

If not instructed by you to the contrary by 21st November, 2001, we suppose that you desire us to take over the representation for the German and Austrian parts of the European patent and shall file a corresponding petition and a German translation with the German Patent Office. Furthermore, we shall pay the respective official fee. As usual, we shall then not see to the annuity reminders and payments for Germany and Austria.

Yours faithfully,



A. Frhr. Riederer von Paar

Encs.:

Copy of our petition of 19-10-01

Decision of 11-10-01 to grant the European Patent

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 689/PCT/CA	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/IT 01/ 00117	International filing date (day/month/year) 09/03/2001	(Earliest) Priority Date (day/month/year) 31/03/2000
Applicant CSELT-CENTRO STUDI E LABORATORI TELECOMUNICAZIONI;		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

5

☐ as suggested by the applicant.

☐ None of the figures.

☐ because the applicant failed to suggest a figure.

☒ because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IT 01/00117

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06T15/70

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
IPC 7 G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, COMPENDEX, IBM-TDB, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 710 929 A (AT & T CORP) 8 May 1996 (1996-05-08) abstract; figures 1-4 column 1, line 11 - line 53 ----	1-7
A	MORISHIMA S ET AL: "FACIAL EXPRESSION SYNTHESIS BASED ON NATURAL VOICE FOR VIRTUAL FACE-TO-FACE COMMUNICATION WITH MACHINE" PROCEEDINGS OF THE VIRTUAL REALITY ANNUAL INTERNATIONAL SYMPOSIUM, US, NEW YORK, IEEE, vol. SYMP. 1, 18 September 1993 (1993-09-18), pages 486-491, XP000457717 abstract; figure 1 page 487, line 1 -page 488, line 39 ----- -/--	1-7

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

4 July 2001

Date of mailing of the international search report

13/07/2001

Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT 01/00117

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 46974 A (ALFONSI PHILIPPE ;PRONIER JEAN LUC (FR)) 11 December 1997 (1997-12-11) abstract; figure 6 -----	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IT 01/00117

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0710929 A	08-05-1996	AU 3668095 A CA 2162199 A JP 8235384 A	16-05-1996 08-05-1996 13-09-1996
WO 9746974 A	11-12-1997	FR 2749420 A AU 3265397 A EP 0907934 A	05-12-1997 05-01-1998 14-04-1999

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
11 October 2001 (11.10.2001)

PCT

(10) International Publication Number
WO 01/75805 A1

(51) International Patent Classification⁷: G06T 15/70

(21) International Application Number: PCT/IT01/00117

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(25) Filing Language: English

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TO2000A000303 31 March 2000 (31.03.2000) IT

(71) Applicant (for all designated States except US):
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(81) Designated States (national): CA, JP, US.

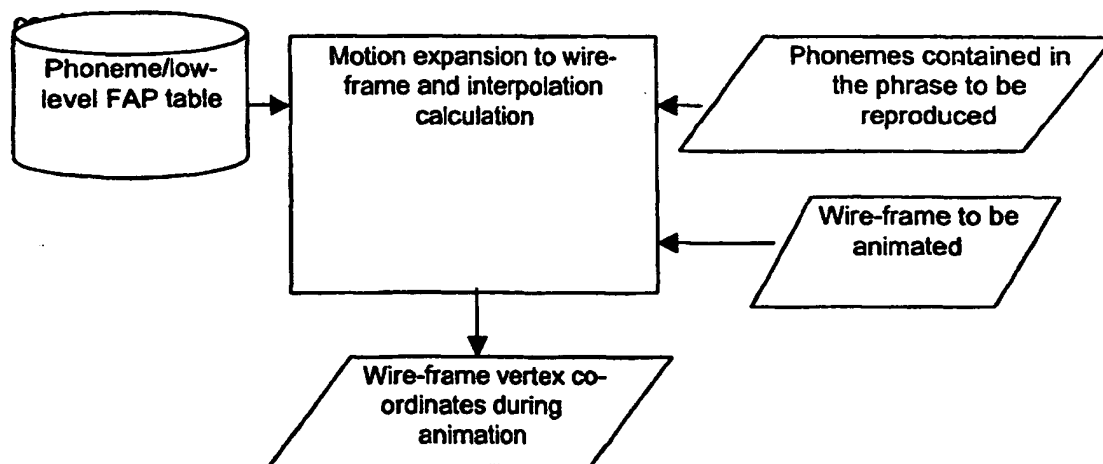
(84) Designated States (regional): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD OF ANIMATING A SYNTHESISED MODEL OF A HUMAN FACE DRIVEN BY AN ACOUSTIC SIGNAL



(57) Abstract: The method permits the animation of a synthesised model of a human face in relation to an audio signal. The method is not language dependent and provides a very natural animated synthetic model, being based on the simultaneous analysis of voice and facial movements, tracked on real speakers, and on the extraction of suitable visemes. The subsequent animation consists in transforming the sequence of visemes corresponding to the phonemes of the driving text into the sequence of movements applied to the model of the human face.

WO 01/75805 A1

"METHOD OF ANIMATING A SYNTHESISED MODEL OF A HUMAN FACE
DRIVEN BY AN ACOUSTIC SIGNAL"

Technical Field

This invention relates to audio-visual or multimedia communication systems, and
5 more particularly, to a method of animating a synthesised model of a human face
driven by an audio signal.

Background Art

Interest surrounding the integration of natural or synthetic objects in the
development of multimedia applications to facilitate and increase user-application
10 interaction is growing, and in this context the use of anthropomorphic models,
destined to facilitate man-machine relationship, is being envisaged. This interest
has been recently acknowledged also by international standardisation
organisations. ISO/IEC standard 14496 "Generic Coding of Audio-Visual Objects"
(commonly known as the "MPEG-4 standard" and hereinafter referred to as such),
15 among other things, aims at establishing a general framework for such
applications.

In such applications in general, regardless of the specific solutions indicated in the
MPEG-4 standard, anthropomorphic models are conceived to assist other
information flows and are seen as objects which can be animated, where
20 animation is driven by audio signals, as, for example, speech. These signals can
also be considered as phonetic sequences, i.e. as sequences of "phonemes",
where a "phoneme" is the smallest linguistic unit (corresponding to the idea of a
distinctive sound in a language).

In this case, animation systems able to deform the geometry and the appearance
25 of the models synchronised to the voice itself need to be developed for the
synthetic faces to assume the typical expressions of speech. The final result to
which development tends is a talking head, or face, which appears natural to the
greatest possible extent.

The application contexts of animated models of this kind can range from Internet
30 applications, such as welcome or help-on-line messages, to co-operative work
applications (e.g. e-mail browsers), to professional applications, such as the
creation of cinema or television post-production effects, to video games, etc.

The models of human faces commonly used are, in general, made on the basis of
a geometrical representation consisting of a three-dimensional mesh structure

(known as a "wire-frame"). Animation is based on the application, in succession, of suitable transforms to the polygons forming the wire-frame (or a respective subset) to reproduce the required effect, i.e. in this specific case, the reproduction of movements related to speech.

5 The solution envisaged by the MPEG-4 standard for this purpose describes the use of a set of facial animation parameters, defined independently with respect to the model, to ensure interoperability of systems. This set of parameters is organised on three levels: the highest level consists of the so-called "visemes" and "expressions", while the lowest level consists of the elementary transforms
10 permitting generic posture of the face. According to MPEG-4 standard, a viseme is the visual equivalent of one or more similar phonemes.

In this invention, the term viseme is used to indicate a shape of the face, associated with the utterance of a phoneme and obtained by means of the application of low-level MPEG-4 parameters, and does not therefore refer to high-
15 level MPEG-4 parameters.

Various systems for animating facial models driven by voice are known in literature. For example, the following documents can be quoted: "Converting Speech into Lip Movements: A Multimedia Telephone for Hard of Hearing People", by F. Lavagetto, IEEE Transactions of Rehabilitation Engineering, Vol. 3, N. 1,
20 March 1995; DIST, Genoa University "Description of Algorithms for Speech-to-Facial Movements Transformation", ACTS "SPLIT" Project, November 1995; TUB, Technical University of Berlin, "Analysis and Synthesis of Visual Speech Movements, ACTS "SPLIT" Project, November 1995. These systems, however, do not implement MPEG-4 standard compliant parameters and, for this reason, are
25 not very flexible.

An MPEG-4 compliant standard animation method is described in Italian Patent Application no. TO98A000842 by the Applicant. This method associates visemes selected from a set, comprising the visemes defined by the MPEG-4 standard and visemes specific to a particular language, to phonemes or groups of phonemes.
30 According to this method, visemes are split into a group of macro parameters, characterising shape and/or position of the labial area and of the jaw of the model, and are associated to respective intensity values, representing the deviation from a neutral position and ensuring adequate naturalness of the animated model. Furthermore, the macro parameters are split into the low-level facial animation

parameters defined in the MPEG-4 standard, to which intensity values linked to the macro parameter values are associated also, ensuring adequate naturalness of the animated model.

Said method can be used for different languages and ensures adequate naturalness of the resulting synthetic model. However, the method is not based on motion data analysis tracked on the face of a real speaker. For this reason, the animation result is not very realistic or natural.

Disclosure of the Invention

The method according to this invention is not language dependent and makes the animated synthetic model more natural, thanks to the fact that it is based on a simultaneous analysis of the voice and of the movements of the face, tracked on real speakers. The method according to this invention is described in the claims which follow.

The use of the so-called "Active Shape Models" (Active Shape Models or ASM, acronym which will be used hereinafter) is suggested to animate a facial model guided by voice in the documents "Conversion of articulatory parameters into active shape model coefficients for lip motion representation and synthesis", S. Lepsøy and S. Curinga, Image Communication 13 (1998), pages 209-225, and "Active shape models for lip motion synthesis", S. Lepsøy, Proceedings of the International Workshop on Synthetic-Natural Hybrid Coding and Three Dimensional Imaging (IWSNHC3DI 97), Rhodes (Greece), September 1997, pages 200-203, which specifically deal with the problem of motion representation conversion. The active shape model method is a representation technique for distributing points in space, which is particularly useful for describing faces and other transformable objects by means of a few parameters. These active shape models, consequently, permit data quantity reduction. This is the property which will be exploited for the purpose of this invention.

Further details on active shape model theory can be found, for example, in the document by T. F. Cootes, D. Cooper, C. J. Taylor and J. Graham, "Active Shape Models - Their Training and Application, Computer Vision and Image Understanding", Vol. 61, no. 1, Jan. 1995, pages 38-59.

Brief Description of Drawings

Reference is made to the following drawings for further clarification, wherein:

- figure 1 shows three pictures of a human face model: a wire-frame only picture on the left; a picture with homogenous colouring and shading in the middle; a picture with added texturing on the right;
 - figure 2 is a flow chart illustrating the analytic operations associating the language-specific phonetic data and the respective movements of the human face;
 - figure 3 shows as example of phonetic alignment;
 - figure 4 illustrates the set of markers used during a generic motion tracking session;
 - figure 5 is a flow chart illustrating the synthesis operations that convert the phonetic flow of a text used for driving the true facial model animation;
- figure 6 illustrates an example of model animation.

Best mode for Carrying Out the Invention

The following generic premises must be made before describing the invention in detail.

Animation is driven by phonetic sequences in which the instant of time when each phoneme is uttered is known. This invention describes an animation method which is not language dependent: this means that the sequence of operations to be followed is the same for each language for which movement of speech is to be reproduced. This invention permits the association of the respective movements of the human face to the phonetic data which is specific to a language. Such movements are obtained by means of statistic analysis, providing very realistic animation effects. In practice, given the case of a model obtained on the basis of a wire-frame, animation consists in applying a set of movements, created as movements relative to a basic model, representing an inexpressive or neutral face, as defined in the MPEG-4 standard, to the vertices of the wire-frame. These relative movements are the result of a linear combination of certain basic vectors, called auto-transforms. One part of the analysis, described below, will be used to find a set of such vectors. Another part will be used to associate a transform, expressed in terms of low-level animation parameters - the so-called FAPs (Facial Animation Parameters), defined in the MPEG-4 standard - to each phoneme.

The animation, or synthesis, phase will then consist in transforming the sequence of visemes, corresponding to the phonemes in the specific driving text, into the

sequence of movements for the vertices of the wire-frame on which the model is based.

A human face model, created on the basis of a wire-frame structure, is shown in figure 1 to facilitate the comprehension of the following description. Number 1 indicates the wire-frame structure, number 2 is associated to the texture (i.e. to a surface which fills the wire-frame crossing the vertices of the wire-frame itself) and number 3 indicates the model completed with the picture of a real person. The creation method of a model on the basis of the wire-frame is not part of this invention and will not be further described herein. An example of the process related to this creation is described by the Applicant in Italian patent application no. TO 98A000828.

Figure 2 illustrates the analytic phase related to the process according to this invention in greater detail.

A speaker 4 utters, in one or more sessions, the phrases of a set of training phrases and, while the person speaks, both the voice and the facial movements are recorded by means of suitable sound recording devices 5 and television cameras 6. At the same time, a phonetic transcription of the uttered texts is made to obtain the phonemes present in the text.

The voice recording devices can be analogue or digital devices providing an adequate quality to permit subsequent phonetic alignment, i.e. to permit the identification of the instants of time in which the various phonemes are uttered. This means that the temporal axis is split into intervals, so that each interval corresponds to the utterance of a certain phoneme ("Audio segmentation" step in figure 2). An instant is associated to each interval, instant in which the phoneme is subjected to the minimal influence of the adjacent phonemes. Hereinafter, the instant described above will be understood when reference is made to a temporal instant linked to a phoneme.

Reference can be made to figure 3 and to Table 1 below, both pertaining to the phonetic analysis and phonetic transcription, with respective timing, of the phrase "Un trucchetto geniale gli valse l'assoluzione" to clarify the concept of phonetic alignment.

TABLE 1

#	0.014000
---	----------

u	0.077938
n	0.166250
t	0.216313
r	0.246125
u	0.296250
k:	0.431375
'e	0.521872
t:	0.619250
o	0.695438
Dg	0.749188
e	0.811375
n	0.858938
j	0.920625
'a	1.054101
l	1.095313
e	1.153359
Gl	1.254000
i	1.288125
v	1.339656
'a	1.430313
l	1.464000
s	1.582188
e	1.615688
l	1.654813
a	1.712982
s:	1.840000
o	1.873063
l	1.899938
u	1.966375
Ts:	2.155938
j	2..239875
'o	2.364250
n	2.416875

e	2.606188
@	2.617500

Voice and movement are recorded in a synchronised fashion. Consequently, phonetic alignment provides the information on which phoneme was uttered in each frame. This information permits estimation of the geometric equivalent of the face for each phoneme of the alphabet.

Again with reference to figure 2 and considering the recording of facial movements, this recording is advantageously obtained by means of the "motion tracking" technique, which permits very plausible animation based on examination of movements of a set of markers located at significant facial features, e.g. the corners of the eyes, the edge of the lips and the face. These markers are indicated with number 7 in figure 4. The points selected for the markers will be called "landmarks" or "feature points". The markers are generally small objects, the special position of which can be detected by means of optical or magnetic devices. The motion tracking technique is well known in the sector and does not require further explanation herein. A certain number of phrases, at least one hundred, need to be recorded for each language, to obtain a significant set of data. Consequently, due to the limitations of motion tracking device internal storage capacity and errors in phrase reading, the recording should preferably be carried out in several sessions, each of which will be dedicated to one or more phrases.

The data obtained by tracking the motion of markers 7 consist of a set of co-ordinates which are not suitable for direct analysis for several reasons. This is because differences in the position of the subject will result if several shooting sessions are carried out. Furthermore, the inevitable head movements must be deleted from the data. The objective is to model the movements related to a neutral posture of the face and not the absolute movements. Aspects will also depend on the devices employed. Errors in recorded data may occur, such as sudden movements and disappearance of some markers for a certain time. These errors require a correction phase in order to obtain reliable data. In other words, correction and normalisation of raw data is required.

For this purpose, at the beginning of each recording, the speaker's face must assume, as far as possible, the neutral position of the face defined in the MPEG-4 standard. Normalisation (or training data cleaning) consists in aligning a set of

points, corresponding to markers 7, with the respective feature points in a generic model of a neutral face. Spatial orientation, position and dimension of this facial model are known. The parameters of this transformation are computed on the basis of the first frame in the recording. The reference to a frame in the sequence is required because the markers 7 may not be in the same position in different recordings. This operation is carried out for each recorded sequence.

In practice, a certain number of markers, e.g. three, used for the recording lie on a stiff object which is applied to the forehead (the object indicated with number 8 in figure 4) and are used to nullify the inevitable movements of the subject's entire head during recording. As an example, for the sake of simplicity, we can suppose that the first three markers are used. Consequently, the sets of co-ordinates are rotated and translated for all frames subsequent to the first in a sequence, so that the first three markers coincide with the corresponding markers in the first frame. After this operation, the first three markers are no longer used. Furthermore, the positions of the feature points on the real face of each picture will need to coincide to the greatest possible extent with the positions of the model chosen as the neutral face, and this entails scaling the recorded picture to adapt it to the dimensions of the model, and translating it. As mentioned, the first three markers are no longer used for this phase.

In order to handle a larger quantity of movement data (and, for some embodiments, also to reduce the quantity of data to be transmitted), a compressed representation of the movements must be found. This compression exploits the fact that movement in various areas of the face is correlated: consequently, according to this invention, the numeric representation of the movements is compressed and expressed, as mentioned above, as combinations of a few basic vectors, called auto-transforms. The auto-transforms must allow the closest possible approximation of facial movements contained in the recorded and transformed sequence. It is emphasised that the movements herein treated relate to a neutral posture. The objective of compression is reached by means of principle component analysis (PCA), a constituent part of ASM. The main components resulting from this analysis are identical to auto-transforms and have the same meaning in the invention.

The posture of the face (i.e. the positions of feature points) assumed during speech, can be approximated with a certain accuracy as a linear combination of

auto-transforms. These linear combinations offer a representation of visemes being expressed as positions of feature points (by means of lower level parameters). The coefficients of the linear combination are called ASM parameters. Summarising, a vector x , containing the co-ordinates of feature points, is the resulting transform with respect to a neutral face, with co-ordinates in a vector \bar{x} , by means of the sum $x = \bar{x} + Pv$ where P is a matrix containing the auto-transforms as columns and v is a vector with ASM parameters.

The ASM model permits expression of the posture assumed by the face during motion tracking by means of a vector consisting of a few parameters. For the purpose of example, the co-ordinates of 41 markers can be approximated with satisfying results using 10 ASM parameters. Furthermore, these operations suppress a component of noise inherent to the acquisition system, i.e. which is not correlated to facial movement.

The viseme calculation phase follows, after collecting voice and movement information.

The objective of this phase is to determine a vector of ASM parameters associated to each single phoneme, i.e. the viseme. The basic criterion is to create a synthesis (i.e. animation) which can best approximate the recorded movement. It is important to stress that this criterion is adopted in the invention to estimate the parameters used in the synthesis phase; this means that it is possible to reproduce the movement of any phrase, not only the phrases belonging to the set of phrases recorded during motion tracking. The animation, as mentioned, is guided by phonemes, which are associated to the respective temporal instants. A very discontinuous representation of movement corresponding to the instants of time associated to the phonemes would result if the visemes associated to the individual phonemes of an animation driving test were used directly. In practice, the movement of the face is a continuous phenomenon and, consequently, contiguous visemes must be interpolated to provide a continuous (and consequently more natural) representation of motion.

Interpolation is a convex combination of visemes to be computed in which the coefficients of the combination (weights) are defined according to time. Note that a linear combination is defined convex when all coefficients are in the $[0, 1]$ interval and their sum is equal to 1. The interpolation coefficients generally have a value other than zero only in a small interval surrounding the instant of utterance, where

the coefficient value reaches the maximum. In the case in which passing interpolation for visemes (forming the interpolation nodes) is required, all coefficients must be equal to zero in the temporal instant of a certain phoneme, except for that of the specific viseme which must be equal to one.

5 An example of a function which can be used for the coefficients follows:

$$\beta_n(t) = \begin{cases} \cos^2\left(\frac{\pi}{2} \frac{t-t_n}{t_{n+1}-t_n}\right); & t \in [t_n, t_{n+1}] \\ \cos^2\left(\frac{\pi}{2} \frac{t-t_n}{t_n-t_{n-1}}\right); & t \in [t_{n-1}, t_n] \\ 0; & t \in [t_{n-1}, t_{n+1}] \end{cases}$$

where t_n is the instant of utterance of the n th phoneme.

The operations described hereinafter are used to respect the approximation criterion of the recorded movement with the synthesised movement. The viseme vectors can be grouped in rows forming a matrix V . The coefficients of the convex combination can be in turn grouped in a row vector \bar{c} . The convex combination of visemes is consequently formed by the product $\bar{c}V$. The vector of the coefficients is a function of time and a matrix C can be formed in which each row contains the coefficients of an instant in time. For the analysis, the instants for which motion tracking data exists are selected. The product CV contains rows of ASM vectors which can approximate the natural movement contained in tracking data. The purpose of this step is to determine the elements in the V matrix containing the visemes, so as to minimise the gap between natural movement (that of the observed frames) and the synthesised movement. Advantageously, the mean square distance between the rows of the product CV and the ASM vectors, representing the recorded movement, is minimised, as defined by the Euclidean rule.

After computing the visemes, the following step consists in passing from the compressed representation, obtained by means of the operations described above, to a position in space of the feature points defined in the MPEG-4 standard. Considering that the computed visemes are vectors containing ASM coefficients, conversion can be obtained by means of a simple matrix product, as

described in the active shape model theory. A vector containing the feature point transform is obtained by multiplying the auto-transform matrix for the ASM vector (as a column).

In turn, the facial animation parameters on a lower level express the position of feature points related to an inexpressive face. Consequently, the translation of visemes, represented as positions of feature points on these low-level parameters, is immediate.

After performing the operations described above on all the phrases of the training set, the table linking the low-level facial animation parameters to the phonemes, which will then be used in the synthesis (or animation) phase, is made.

Reference is hereto made to the chart in figure 5, illustrating the operations related to synthesis or animation of the model starting from a given driving text.

"Synthesis" herein means computing movements for a wire-frame on the basis of phonetic and temporal information, so that the transforms are synchronised with associated sounds and closely reproduce lip movement. Synthesis is, consequently, the process which converts a sequence of visemes into a sequence of wire-frame co-ordinates, representing the face to be animated. Synthesis is based on the correspondence table between phonemes and low-level MPEG-4 FAPs, resulting from the analysis process. Consequently, the animation process takes the wire-frame to be animated, the phonemes contained in the phrase to be reproduced and the low-level mi/FAPs table as inputs. The wire-frame is specified by a set of points in space, by a set of polygons which exploit the previous points as vertices and by information inherent to the appearance of the surface, such as colour and texture.

To reproduce a given driving signal (generally, a phrase), firstly the phrase must be transcribed as a sequence of phonemes, each of which is labelled by the instant in time in which it was uttered, as shown in the example in Table 1. A discreet sequence of visemes corresponds to this discreet sequence. The sequence of phonemes can be obtained in different ways, according to the source of the phrase to be reproduced. In the case of synthesised sound, in addition to generating the wave shape of speech, the synthesiser will generate the phonetic transcription and respective time reference. In the case of natural voice, this information must be extracted from the audio signal. Typically, this operation can be carried out in two different ways, according to whether the phonemes contained

in the uttered phrase are known or not. The first case is called "phonetic alignment" and the second case is called "phonetic recognition", which generally provides lower quality results. These proceedings are all known in literature and are not the subject of this invention.

5 To ensure the naturalness and fluidity of movement of the animated face, a high number of pictures or frames per second (e.g. at least 16 frames) is required. This number is considerably higher than the number of phonemes contained in the driving signal. Consequently, numerous intermediate movements of the face contained between two subsequent phonemes will need to be determined, as
10 shown in better detail below.

With reference to the creation of a single frame, it is stressed that facial animation parameters are taken from feature points. For this reason, which vertices in the wire-frame correspond to the considered feature points must be known. This information is obtained by means of a method which is similar to that used in the
15 analytic phase, i.e. by multiplying the coefficient vector related to the primary components by the primary component matrix. In this way, the FAPs are transformed into movements of the vertices. Considering that the MPEG-4 standard specifies that the wire-frame should have a predefined spatial orientation, the FAP transformation into movements is immediate, considering that the FAPs
20 are specified in units of measure related to the dimension of the face.

The model reproducing the face comprises, in general, a number of vertices which is much higher than the number of feature points. The movement of feature points must be extrapolated to obtain a defined movement of all vertices. The motion of each vertex not associated to a feature point will be a convex combination of the
25 movements of feature points. The relative coefficients are calculated on the basis of the distance between the vertex to be moved and each of the feature points, and for this purpose the minimum length of distance along the arches of the wire-frame, known as Dijkstra's distance, is used (E. Dijkstra, "A note on two problems in connection with graphs", *Numerische Mathematik*, vol. 1, p. 269-271, Springer
30 Verlag, Berlin, 1959). The contribution provided by a feature point to a vertex is inversely proportional to Dijkstra's distance between two points, to the n th power. This power is determined with the objective of providing greater importance to feature points close to the vertex to be moved and is independent from the dimension of the wire-frame.

The latter operation results in a representation of the viseme on the entire wire-frame. The use of the method described above presents the advantage that all feature points act on all vertices, and therefore the specification of a sub-set of such points for each vertex to be moved is no longer required. This permits
5 elimination of a work phase which otherwise must be carried out manually and is, consequently, extremely expensive, considering the high number of vertices in wire-frames also in the case of relatively simple models.

Figure 6 shows how the visemes corresponding to the phonemes *a*, *m*, *p*., *u* (EURO-MPPA phonetic symbols) in the Italian language are expressed by altering
10 the structure of an entire textured wire-frame.

As previously mentioned, temporal evolution must be considered for synthesising a phrase. The starting point is the sequence of known visemes in discreet instants. In order to use a frequency of frames, variable or not, at will, the movement of the model is represented as a continuous function in time. The representation as a
15 continuous function in time is obtained by the interpolation of visemes, achieved in a similar fashion as described in the analytic phase. A scaling acting as a coefficient in a convex combination is associated to each viseme; this coefficient is a continuous function of time and is computed according to the interpolation routine previously used in the analytic phase for computing the visemes. For
20 reasons of efficiency, the computation is preferably carried out by interpolation and the number of feature points is lower than the number of vertices. The continuous representation can be sampled at will to obtain the individual frames which shown in sequence and synchronised with sound, reproduce an animation on a computer. The description herein is provided as a non-limiting example and obviously
25 variations and changes are possible within the scope of protection of this invention.

Claims

1. Method of animating a synthesised model of a human face driven by an audio signal, comprising an analytic phase, in which an alphabet of visemes is determined, i.e. a set of information representing the shape of a face of a speaker corresponding to phonetic units extracted from a set of audio training signals, and a synthesis phase, in which the audio driving signal is converted into a sequence of phonetic units associated to respective temporal information, whereas the sequence of visemes, corresponding to the phonetic units of the set comprised in the audio driving signal, are determined in the analytic phase, and the transforms required to reproduce the sequence of visemes are applied to the model

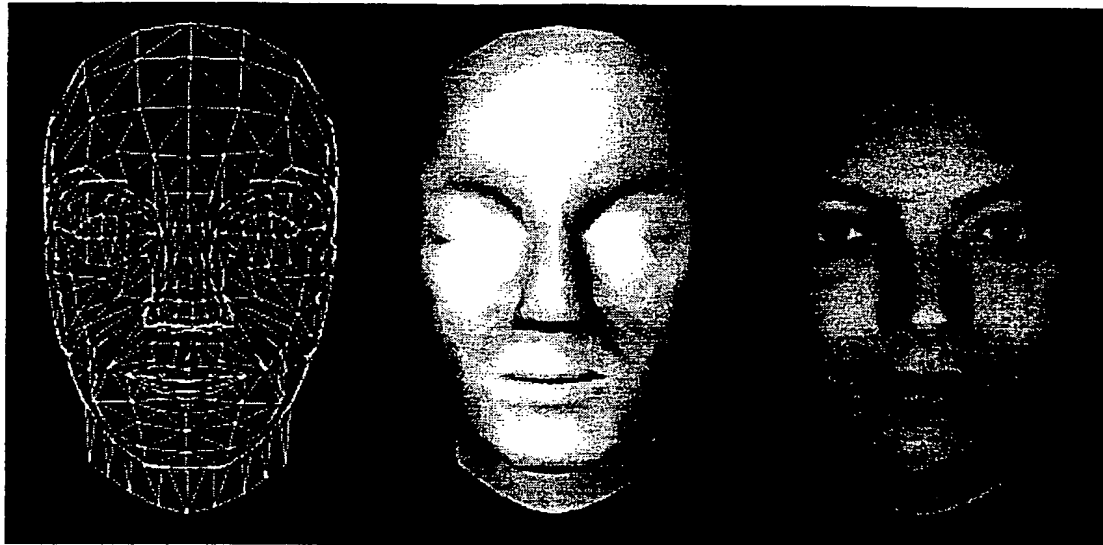
characterised by the fact said analytic phase provides an alphabet of visemes, determined as active shape model parameter vectors, to which the respective transforms of the model, expressed as parameters of low-level facial animation compliant with standard ISO/IEC 14496, are associated. During both the analytic phase and the synthesis phase, the sequences of visemes, corresponding to the phonetic units of the audio training signal and of the audio animation driving signal, respectively, are transformed into continuous representations of movement by means of viseme interpolation, conducted as convex combinations of the visemes themselves to which combination coefficients, which are continuous functions of time, are associated, the combination coefficients carried out in the synthesis phase being the same as those used for the analytic phase combination.

2. Method according to claim 1, characterised by the fact that the coefficients of said convex combinations are functions of the following type:

$$\beta_n(t) = \begin{cases} \cos^2\left(\frac{\pi}{2} \frac{t-t_n}{t_{n+1}-t_n}\right); & t \in [t_n, t_{n+1}] \\ \cos^2\left(\frac{\pi}{2} \frac{t-t_n}{t_n-t_{n-1}}\right); & t \in [t_{n-1}, t_n] \\ 0; & t \in [t_{n-1}, t_{n+1}] \end{cases}$$

3. Method according to claim 1 or 2, characterised by the fact that the wire-frame vertices, corresponding to the model feature points, on the basis of which facial animation parameters are determined in the analytic phase, are identified and said viseme interpolation operations are conducted by applying transforms on feature points for each viseme, for animating a wire-frame based model.
4. Method according to claim 3, characterised by the fact that, for each position to be assumed by the model in said synthesis phase, the transforms are applied only to the vertices of the wire-frame corresponding to the feature points and the transforms are extended to the remaining vertices by means of a convex combination of the transforms applied to the vertices of the wire-frame corresponding to the feature points.
5. Method according to claim 1, characterised by the fact that said visemes are converted into co-ordinates of the feature points of the face of the speaker, followed by conversion of said co-ordinates into said low-level facial animation parameters, as described in standard ISO/IEC 14496.
6. Method according to claim 5, characterised by the fact that said low-level facial animation parameters, representing the co-ordinates of feature points, are obtained by analysing the movements of a set of markers (7) which identify the feature points themselves.
7. Method according to claim 6, characterised by the fact that the data representing the co-ordinates of the feature points of the face are normalised according to the following method:
 - a sub-set of markers are associated to a stiff object (8) applied to the forehead of the speaker;
 - the face of the speaker is set, at the beginning of the recording, to assume a position corresponding as far as possible to the position of a neutral face model, as defined in standard ISO/IEC 14496, and a first frame of the face in such neutral position is obtained;for all frames subsequent to the first frame, the sets of co-ordinates are rotated and translated so that the co-ordinates corresponding to the markers of said sub-set coincide with the co-ordinates of the markers of the same sub-set in the first frame.

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1

2

3

Fig. 1

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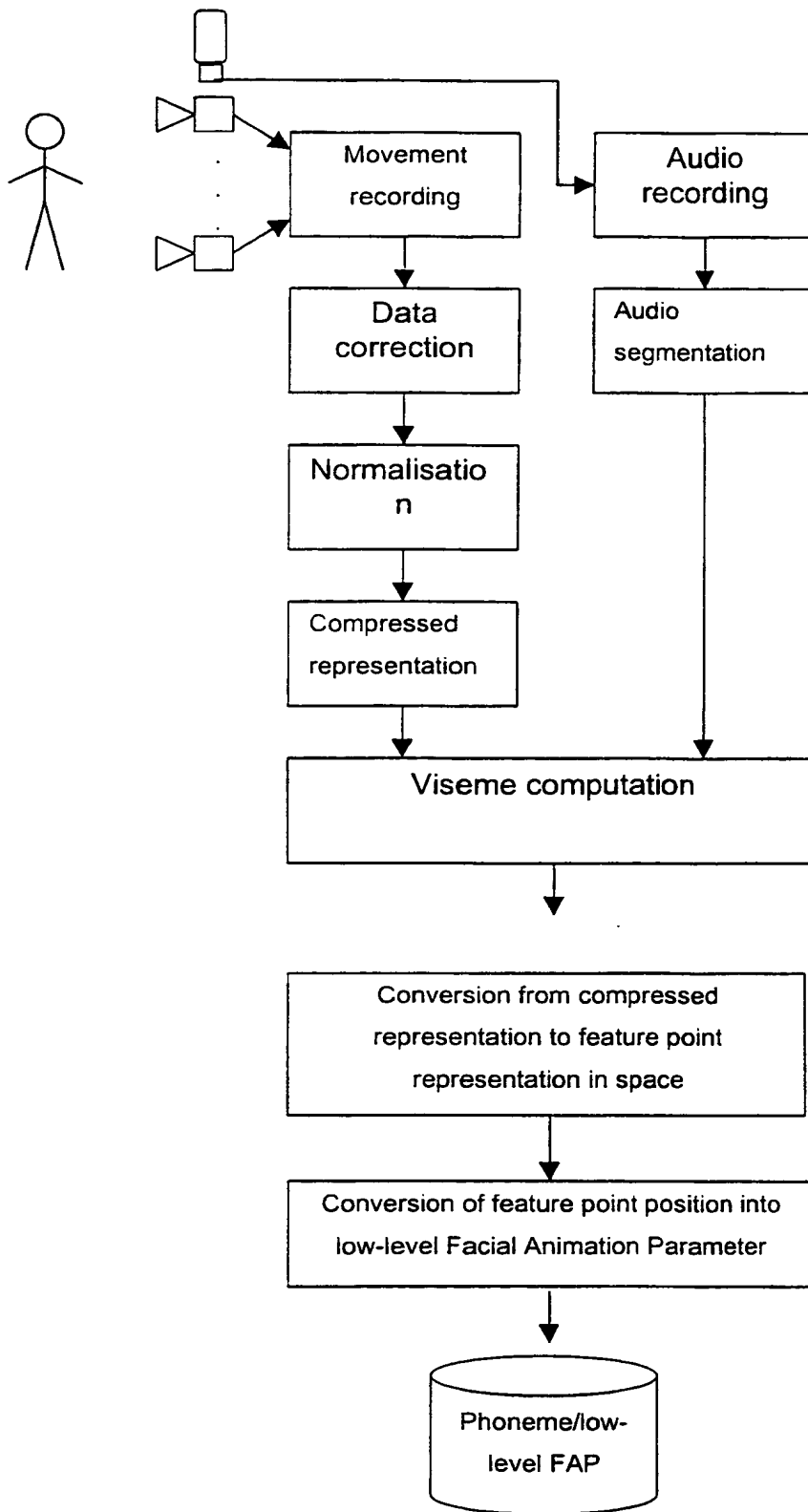


Fig. 2 -

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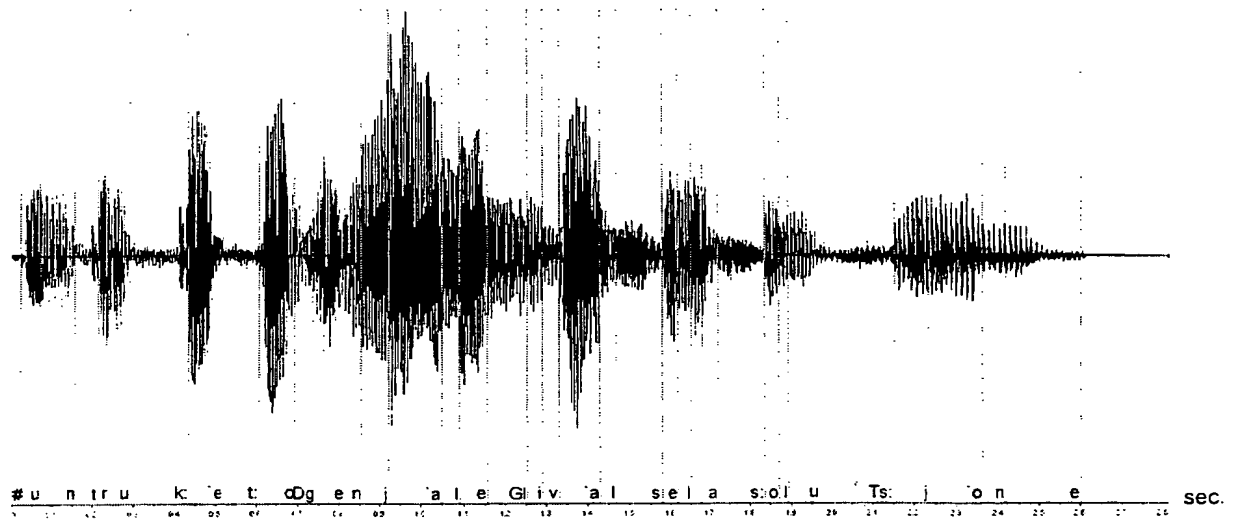


Fig. 3



Fig. 4

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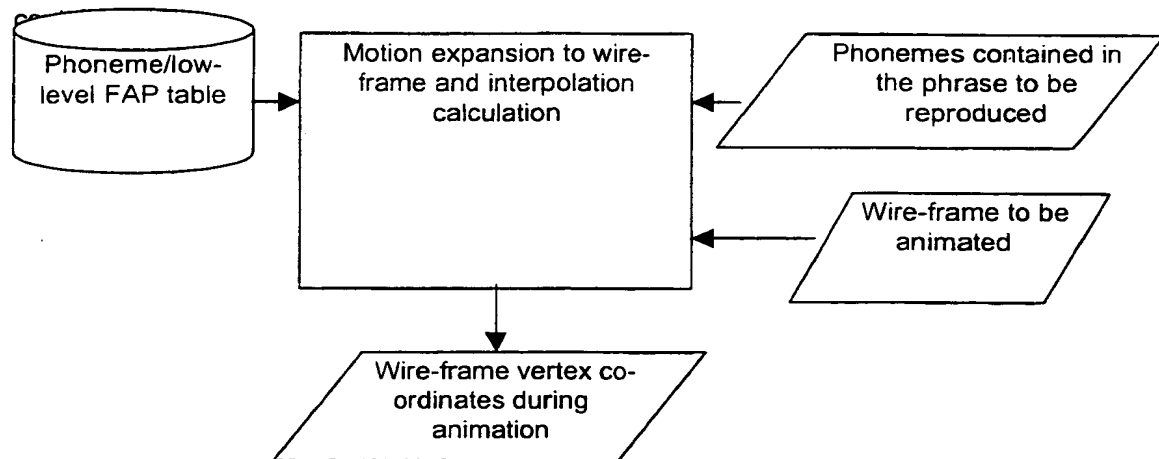


Fig. 5

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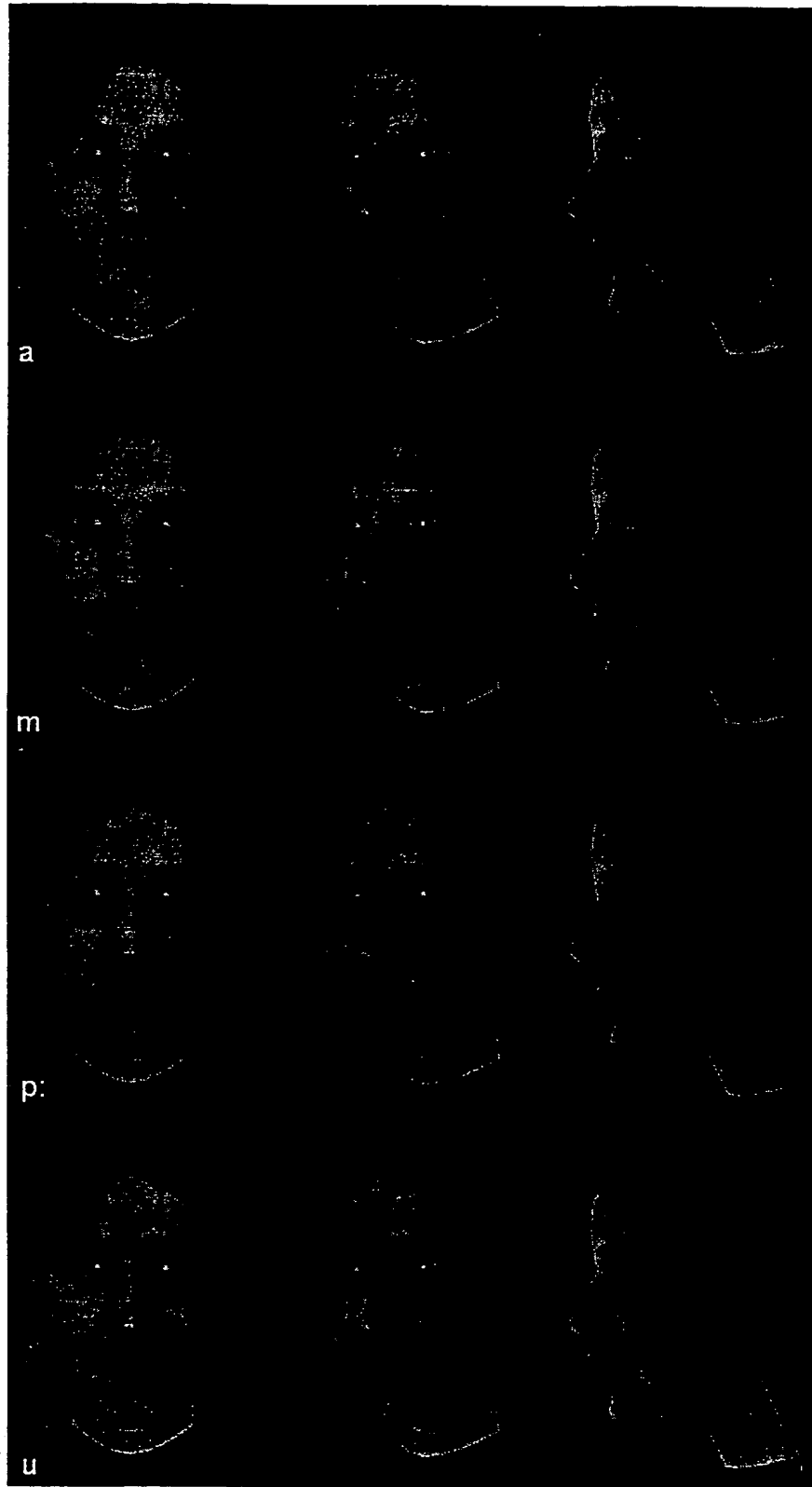


Fig. 6

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IT 01/00117

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06T15/70

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, COMPENDEX, IBM-TDB, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 710 929 A (AT & T CORP) 8 May 1996 (1996-05-08) abstract; figures 1-4 column 1, line 11 - line 53 ---	1-7
A	MORISHIMA S ET AL: "FACIAL EXPRESSION SYNTHESIS BASED ON NATURAL VOICE FOR VIRTUAL FACE-TO-FACE COMMUNICATION WITH MACHINE" PROCEEDINGS OF THE VIRTUAL REALITY ANNUAL INTERNATIONAL SYMPOSIUM, US, NEW YORK, IEEE, vol. SYMP. 1, 18 September 1993 (1993-09-18), pages 486-491, XP000457717 abstract; figure 1 page 487, line 1 -page 488, line 39 --- -/--	1-7

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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- *&* document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT 01/00117

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 46974 A (ALFONSI PHILIPPE ;PRONIER JEAN LUC (FR)) 11 December 1997 (1997-12-11) abstract; figure 6 -----	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IT 01/00117

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			CA	2162199 A	08-05-1996
			JP	8235384 A	13-09-1996
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			EP	0907934 A	14-04-1999